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# The Application of Fracture Mechanics to Estimate the Crack Length for Developing an Inspection Criterion

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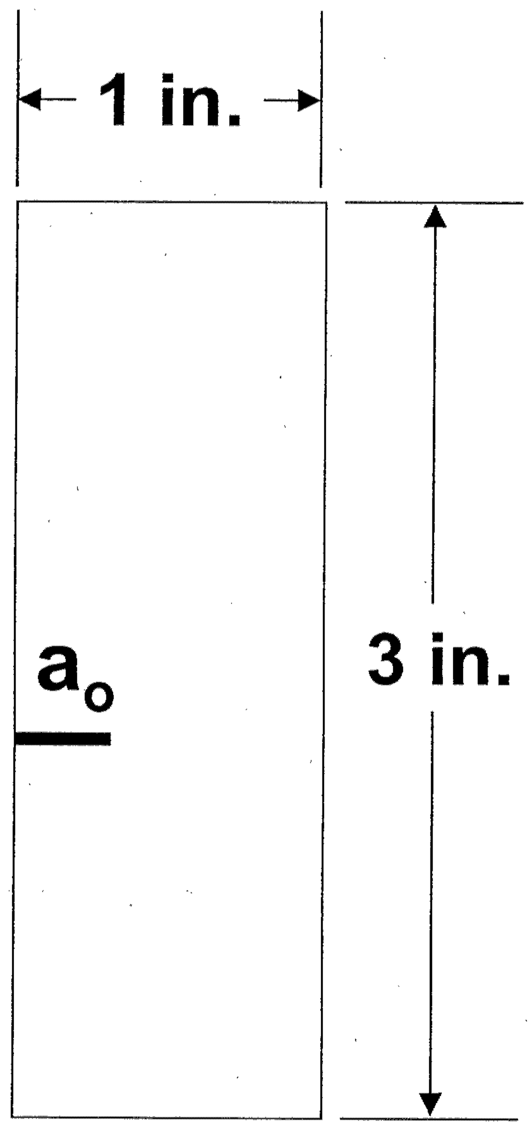
# Objectives:

- Determine the Inherent Critical Initial Crack Size in a Particulate Composite Material for Developing an Inspection Criterion.
- Determine the Statistical Distribution Function of the Inherent Critical Crack Size.

# Specimen Geometry




$a_o$ = 0.0 in.
= 0.1 in.
= 0.2 in.
= 0.3 in.

# Crack Growth Equations

$$K_I = \sigma\ (\pi\ a)^{1/2}\ f\ (a/w)$$

$$f\ (a/w) = 0.7722(a/w)^3 + 0.9253(a/w)^2 + 1.095(a/w) + 1.005$$

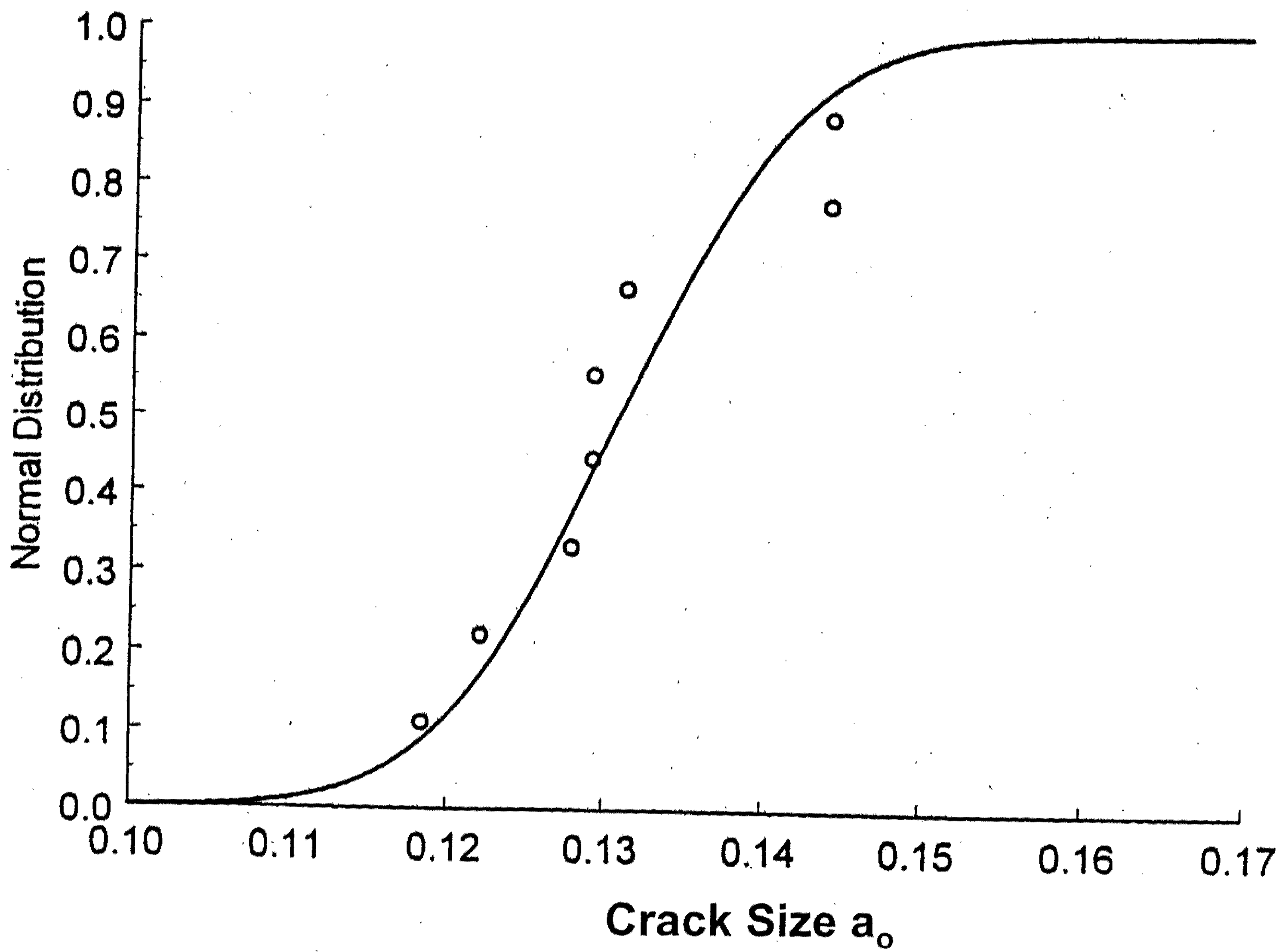
$$K_{IC} = \sigma_c\ (\pi a_c)^{1/2}\ f\ (a_c/w)$$

$$da/dt = Q\ K_I^m$$

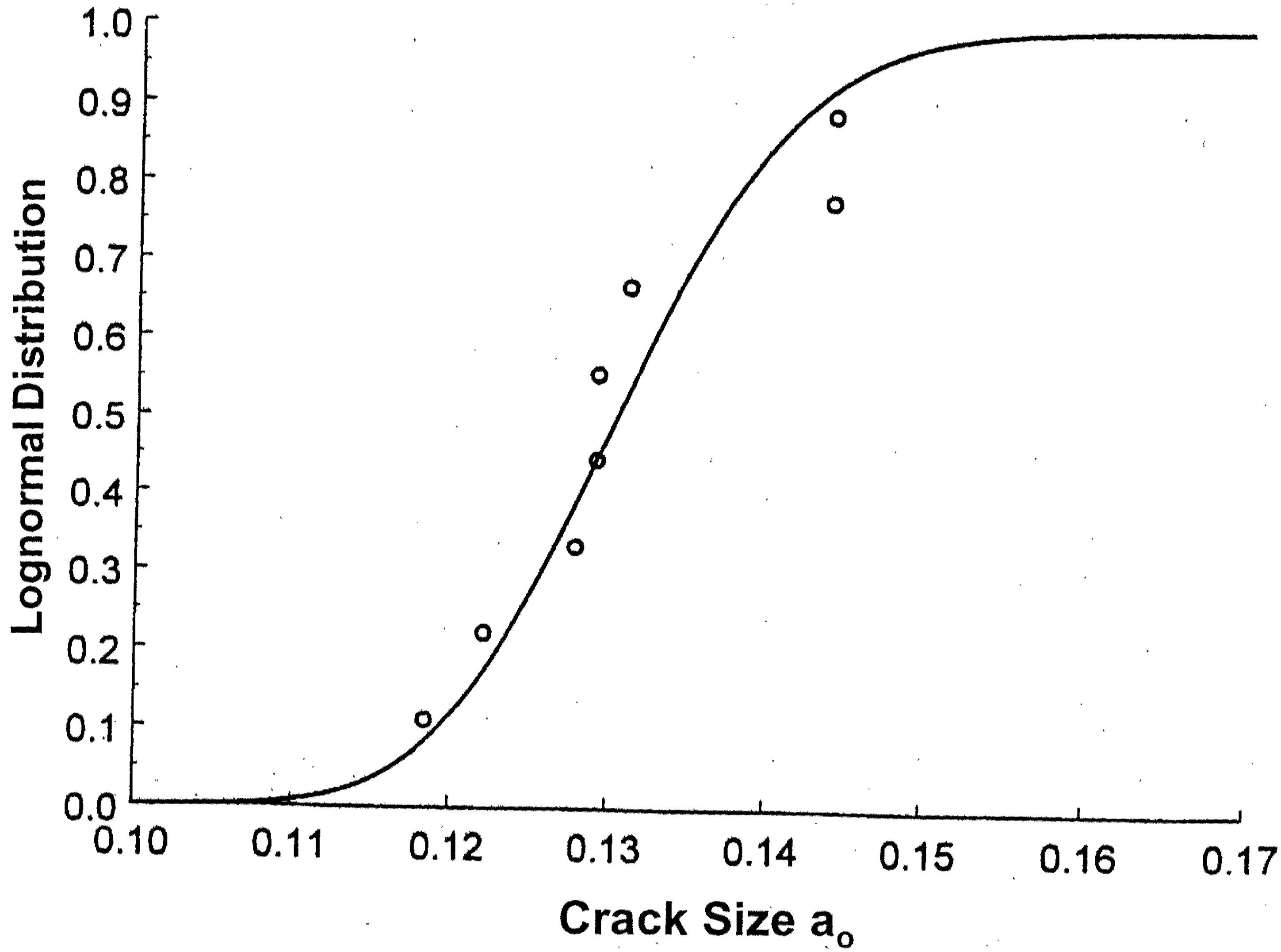
# Statistical Distribution Functions

| | |
|---|---|
| $F_X(x) = \Phi\left(\frac{x-u}{\sigma}\right)$ | **Normal Distribution** |
| $F_X(x) = \Phi\left(\frac{\ln x - u^*}{\sigma^*}\right)$ | **Lognormal Distribution** |
| $F_X(x) = 1 - \exp\,[(x/\beta)^{\alpha}]$ | **Two-Parameter Weibull Distribution** |
| $F_X(x) = \exp\,[-(x/\nu)^{-\kappa}]$ | **Second Asymptotic Distribution of Maximum value** |
| $F_X^*(x) = 1 - F_X(x)$ | **Exceedance Curve.** |

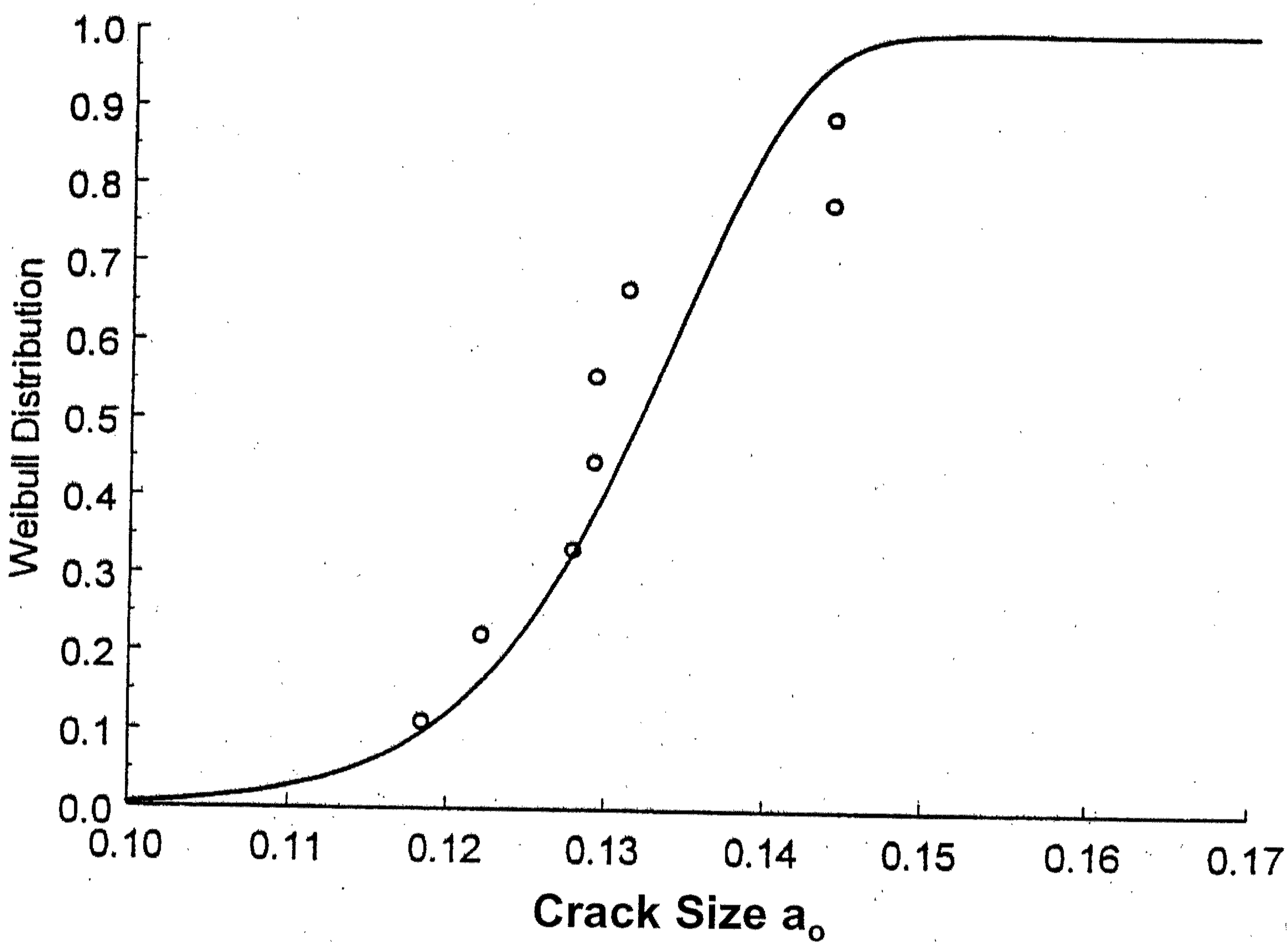
# Normal Distribution Plot for $a_o$



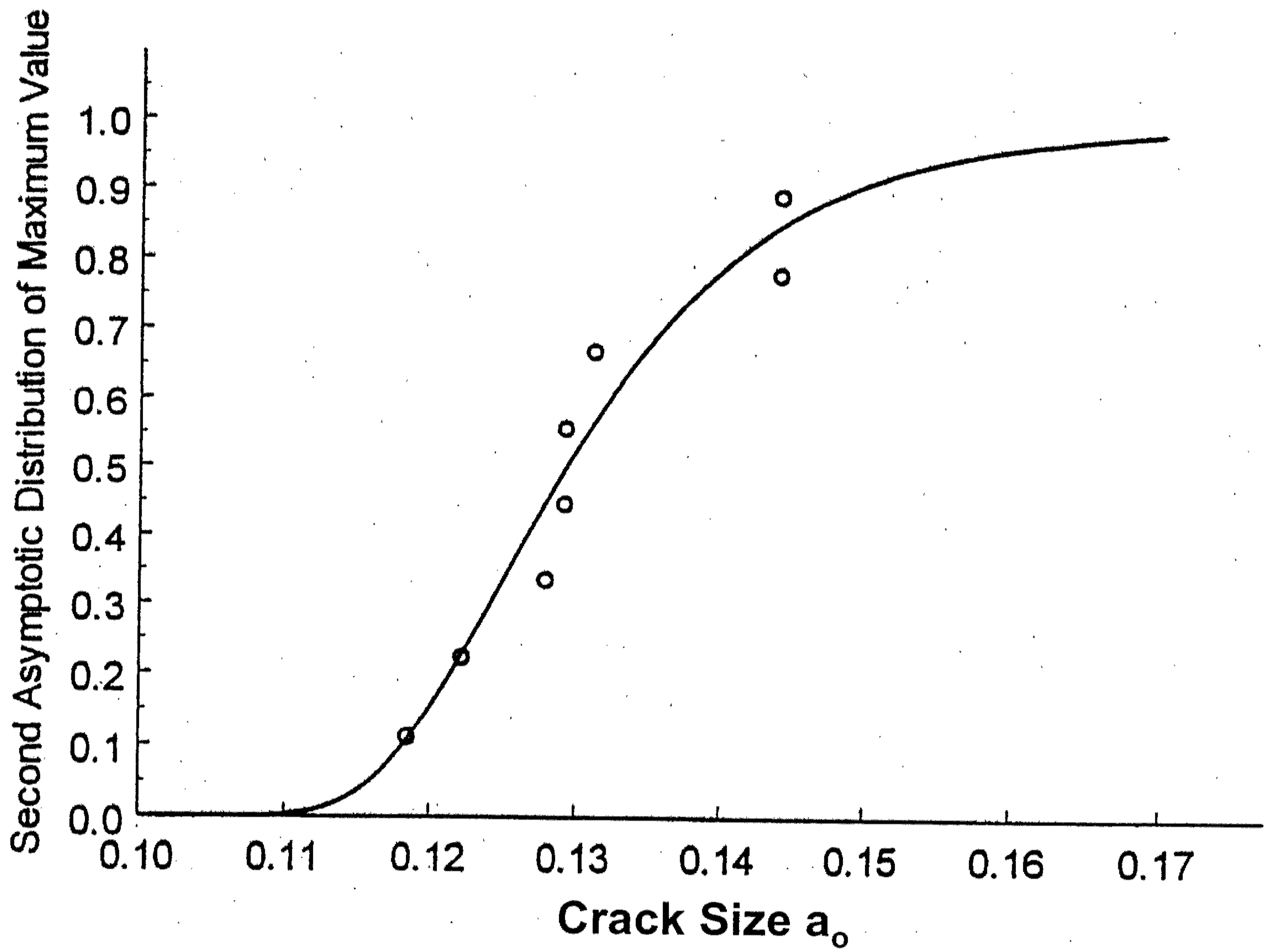
# Lognormal Distribution Plot for $a_o$



# Weibull Distribution Plot for $a_o$



# Second Asymptotic Distribution Plot for $a_o$



# Distribution Parameters for Normal, Lognormal, Weibull and Asymptotic Distributions

Strain Rate = 0.04 $min^{-1}$

| | $a_0$ | $a^*$ | $a_c$ |
|---|---|---|---|
| $u$ | 0.1308 | 0.1344 | 0.1462 |
| $\sigma$ | 0.0092 | 0.0090 | 0.0079 |
| $u^*$ | -2.037 | -2.0092 | -1.9242 |
| $\sigma^*$ | 0.07021 | 0.06692 | 0.053961 |
| $\alpha$ | 17.5546 | 18.4513 | 23.0450 |
| $\beta$ | 0.1348 | 0.1383 | 0.1497 |
| $k$ | 13.2524 | 13.8081 | 17.1205 |
| $\upsilon$ | 0.1258 | 0.1295 | 0.1419 |

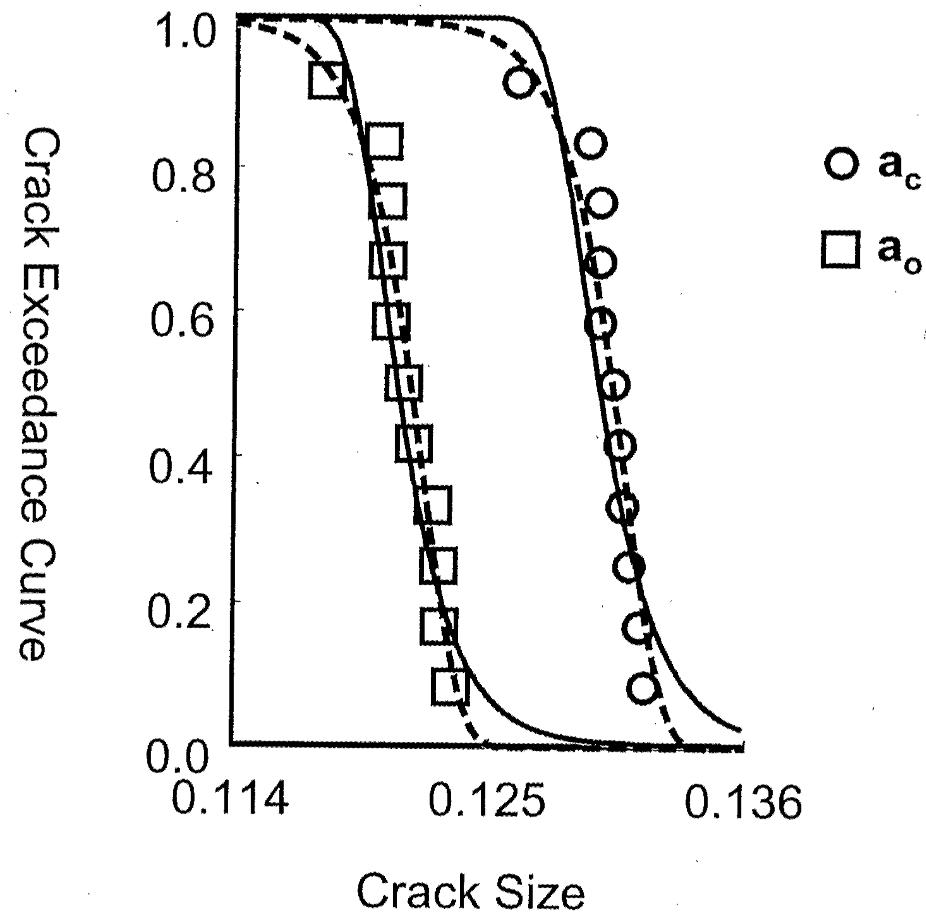
# Distribution Parameters for Normal, Lognormal, Weibull , and Asymptotic Distributions

| Strain Rate = 0.727 min. $^{-1}$ | | | |
|---|---|---|---|
| Parameters | $a_c$ | $a^*$ | $a_o$ |
| $\mu$ | 0.12999 | 0.12131 | 0.11865 |
| $\sigma$ | 0.00152 | 0.00159 | 0.00157 |
| $\mu^*$ | -2.04037 | -2.10951 | -2.13163 |
| $\sigma^*$ | 0.01172 | 0.01315 | 0.01324 |
| $\alpha$ | 80.1416 | 74.4660 | 74.4279 |
| $\beta$ | 0.1308 | 0.1221 | 0.1194 |
| $\kappa$ | 72.4100 | 70.8130 | 71.9883 |
| $\nu$ | 0.1291 | 0.1204 | 0.1178 |

# Distribution Parameters for Normal, Lognormal, Weibull , and Asymptotic Distributions

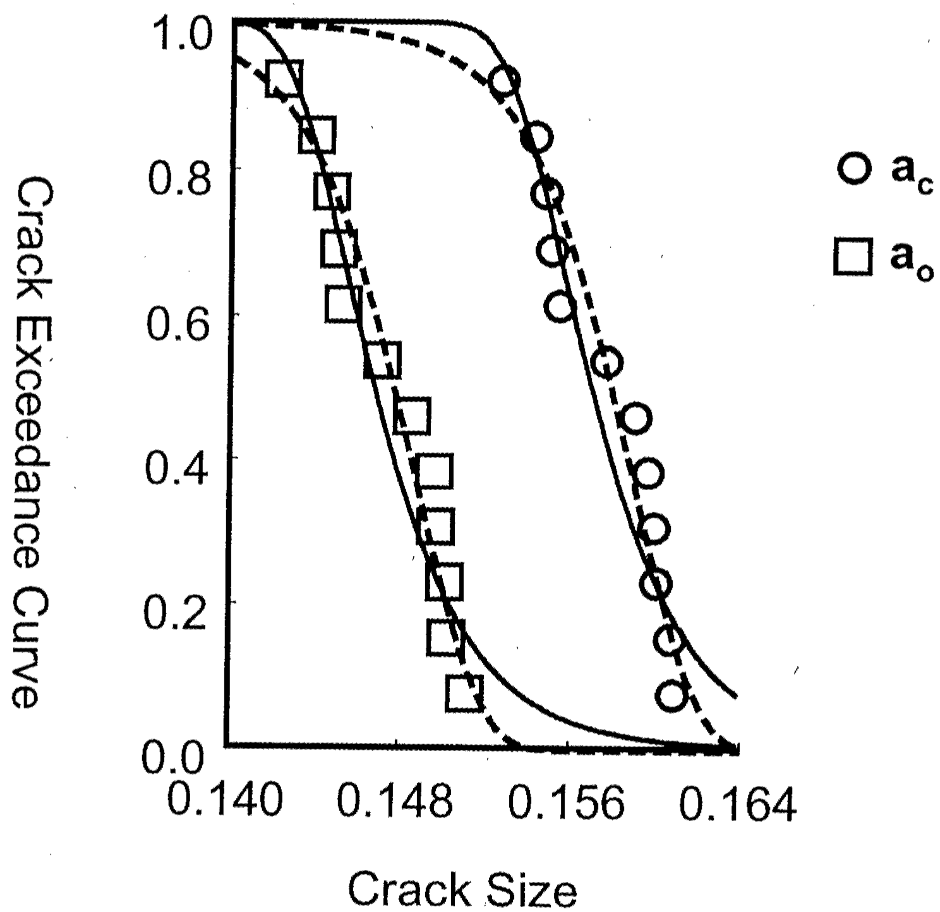
| Strain Rate = 18.182 min. $^{-1}$ | | | |
|---|---|---|---|
| Parameters | $a_c$ | $a^*$ | $a_o$ |
| $\mu$ | 0.15750 | 0.14735 | 0.14597 |
| $\sigma$ | 0.00290 | 0.00296 | 0.00290 |
| $\mu^*$ | -1.84847 | -1.91517 | -1.92456 |
| $\sigma^*$ | 0.01842 | 0.02008 | 0.01989 |
| $\alpha$ | 53.6601 | 49.5994 | 50.0668 |
| $\beta$ | 0.1590 | 0.1488 | 0.1474 |
| $\kappa$ | 51.3708 | 47.7906 | 48.4144 |
| $\nu$ | 0.1559 | 0.1458 | 0.1444 |

# Crack Exceedance Curves for Strain Rate = 0.727 $min^{-1}$



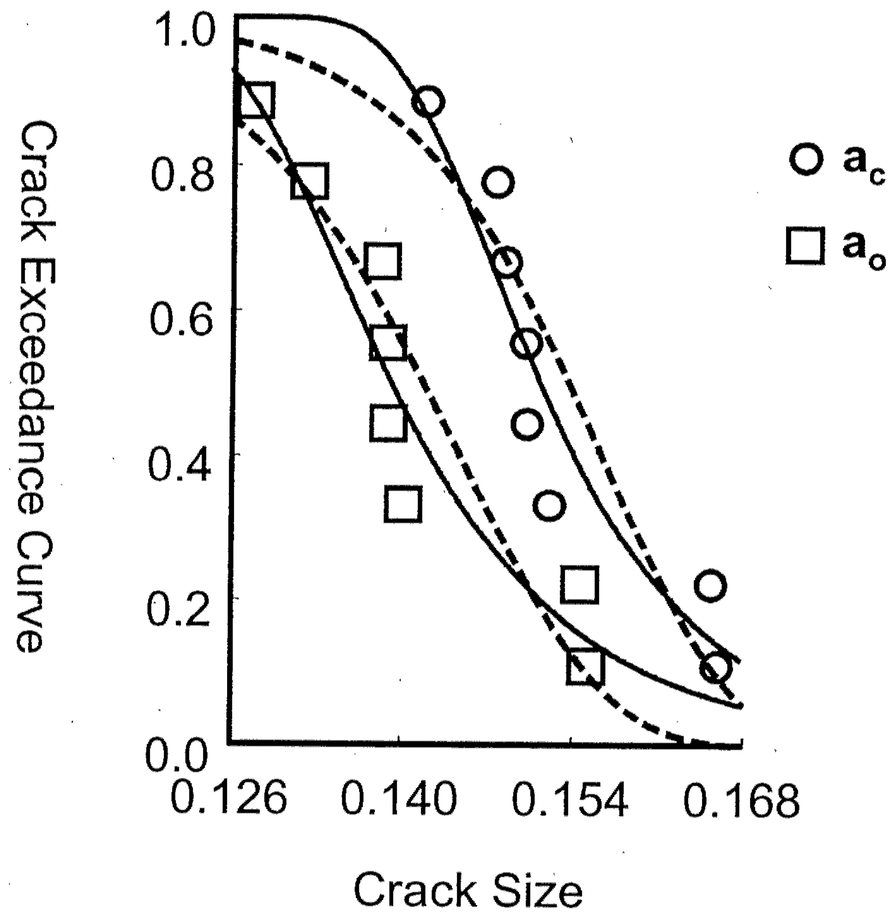

Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.

# Crack Exceedance Curves for Strain Rate = 18.182 min.$^{-1}$




Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.

# Crack Exceedance Curves for Strain Rate = $0.04 min.^{-1}$

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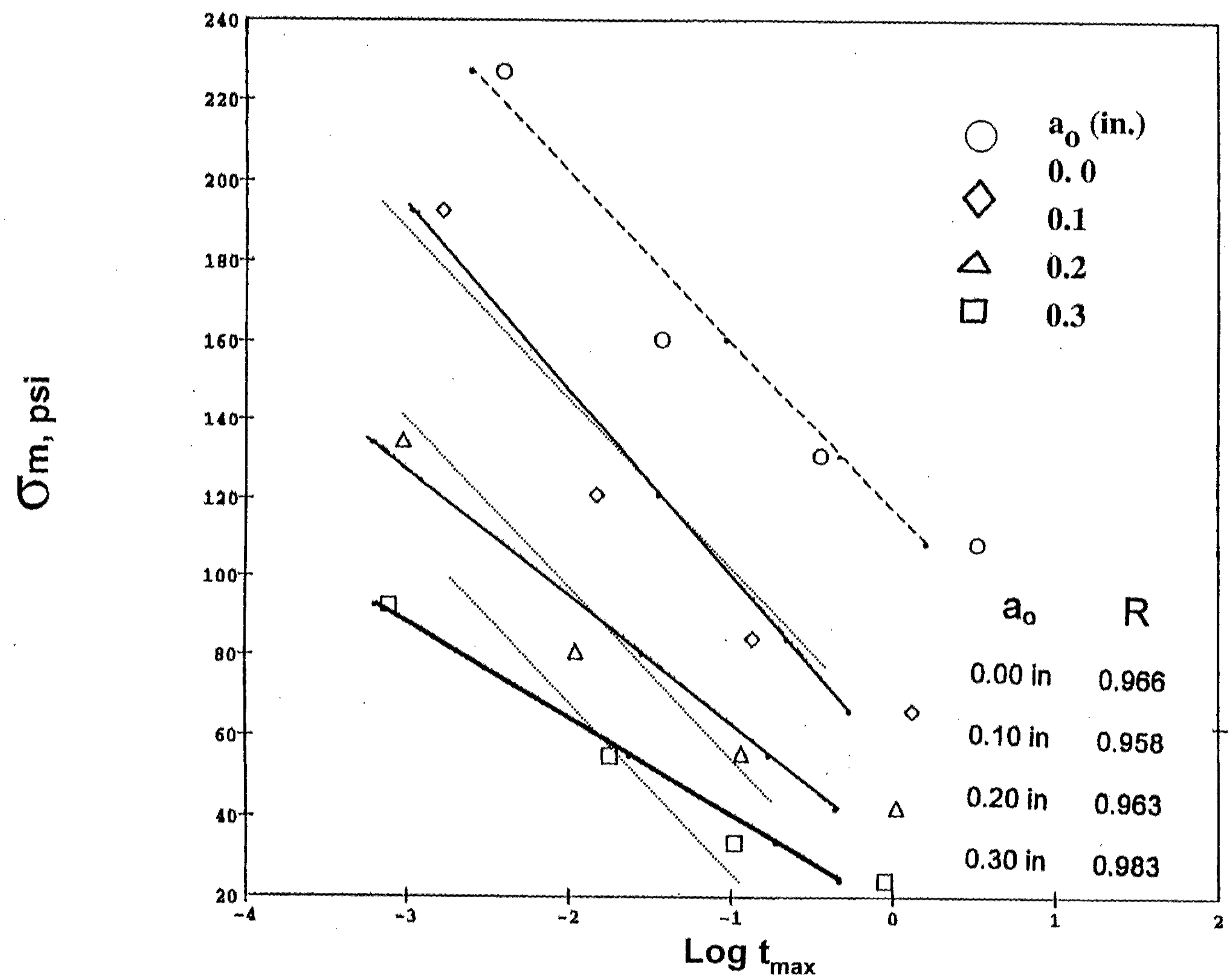


# Maximum Stress Vs Maximum Time

# Conclusions:

- For the material studied, the estimate inherent critical crack size, $a_o$, is insensitive to the strain rate and the averaged value of $a_o$ is 0.132 in., which compares well with experimental value.
- The inherent critical crack size follows the second asymptotic distribution of the maximum value.
- The estimated $a_o$ should be used to develop the inspection criterion.